

NEW SPECIES OF *GALAXIA* (IRIDACEAE) AND NOTES ON CYTOLOGY AND EVOLUTION IN THE GENUS¹

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ABSTRACT

Galaxia kamiesmontana and *G. parva* are new species, both of subgenus *Eurystigma*. *Galaxia kamiesmontana* is restricted to the Kamiesberg in Namaqualand, where it grows in shallow soils overlying rock, while *G. parva* is known only from the Mierkraal flats near Bredasdorp in the southern Cape. Chromosome number is $n = 9$ in *G. kamiesmontana* and $n = 6$ in *G. parva*. Both numbers are new for the subgenus, in which $n = 8, 7,$ and 17 have been recorded. The chromosome number in *G. kamiesmontana* links subgenus *Eurystigma* to the more specialized subgenus *Galaxia* in which $x = 9$ is basic. Chromosome evolution in *Galaxia*, reviewed in the paper, is seen as having proceeded from a base of $x = 9$ by aneuploid reduction to $n = 8, 7$ and ultimately 6 by unequal translocation and centric loss. *Galaxia kamiesmontana* is evidently a primitive relict species retaining the ancestral basic karyotype, while *G. parva*, an inbreeding, autogamous species with a highly derived karyotype is one of the most specialized.

Galaxia is a small genus of Iridaceae subfamily Iridoideae restricted to the winter rainfall area of the southwestern coast and interior of southern Africa. All species of *Galaxia* are small corm bearing plants with a basal rosette of short bifacial leaves and *Crocus*-like flowers with an underground ovary and a perianth tube that raises the flower well above the ground. The flowers are fugaceous, lasting for 3–6 hours, and this, together with their small size, makes the plants very inconspicuous. As a result, the genus is relatively poorly collected. In the recent revision of the genus (Goldblatt, 1979a) I recognized 12 species in two subgenera. The two species described here were discovered subsequent to the publication of the 1979 revision, *G. kamiesmontana* in 1980 and *G. parva* in 1981. Both are clearly very local endemics and in view of the high level of knowledge of the Cape Flora, it seems unlikely that they occur elsewhere.

RELATIONSHIPS

The two new species belong to subgenus *Eurystigma*, in which the stigma lobes are entire, the filaments typically united below and free for some distance above, and the flowers usually variously colored. In contrast, in the more specialized subgenus *Galaxia*, the stigma lobes are irregularly fringed, the filaments typically entirely united and the flowers yellow or, rarely, yellow

and white. Basic chromosome number for the genus is probably $x = 9$ (Goldblatt, 1979a, 1979b), and $x = 9$ is the basic number for subgenus *Galaxia*, in which only multiples of this base occur (Table 1). Until now numbers of $x = 8$ and 7 only, had been recorded in subgenus *Eurystigma* (Table 1), although I postulated that $x = 9$ probably occurred in the ancestral type of this, the less specialized subgenus. Chromosome number has been determined for both new species, *G. kamiesmontana* having $2n = 18$ and *G. parva*, $2n = 12$. Both numbers are thus new for the subgenus and substantially expand the impression of *Galaxia* as a cytologically variable genus. My prediction that $x = 9$ was basic for subgenus *Eurystigma* seems to have been fulfilled with the discovery of this number in *G. kamiesmontana*. The karyotypes of the new species and the cytological evolution of the genus is dealt with in more detail below.

CYTOLOGY

Chromosome numbers were established for *Galaxia kamiesmontana* and *G. parva* using a squash technique described previously (Goldblatt, 1979b). In both species the type collections serve as the voucher specimens for the chromosome counts.

The karyotype of *Galaxia kamiesmontana*, with $2n = 18$, comprises five pairs of larger chro-

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TABLE 1. Chromosome numbers in *Galaxia*. Voucher information for original counts is provided in a footnote to this table. The other counts were previously reviewed by Goldblatt (1979b).

Species	Diploid Number	Mean Length Haploid Chromosome Set μm
Subgenus <i>Eurystigma</i>		
<i>G. kamiesmontana</i> Goldbl.	18 ^a	39.0
<i>G. citrina</i> Lewis	16, 14, 34	39.3
<i>G. barnardii</i> Goldbl.	16, 16 ^a	38.3
<i>G. versicolor</i> Salisb. ex Klatt	16, 14	40.0
<i>G. variabilis</i> Lewis	14	38.9
<i>G. parva</i> Goldbl.	12 ^a	42.0
Subgenus <i>Galaxia</i>		
<i>G. grandiflora</i> Goldbl.	18	—
<i>G. ciliata</i> Persoon	18	—
<i>G. luteo-alba</i> Goldbl.	18, 27	—
<i>G. ovata</i> Thunb.	18, 36, 54 ^a	40.9
<i>G. stagnalis</i> Goldbl.	36	—
<i>G. fugacissima</i> (L. f.) Druce	18, 36	—
<i>G. alata</i> Goldbl.	18, 27	—
<i>G. albiflora</i> Lewis	18	—

^a Voucher data:

G. kamiesmontana—Cape Province, Rooiberg, Kamiesberg, Goldblatt 5560 (MO).

G. barnardii—Cape Province, Caledon, at the western end of town, Goldblatt 6174 (MO).

G. parva—Cape Province, Mierkraal flats, SSW of Bredasdorp, Goldblatt 6181A (MO).

G. ovata—Cape Province, Mierkraal flats, SSW of Bredasdorp, Goldblatt 6928 (MO).

mosomes, 4–6 μm long, and four smaller pairs, ca. 3 μm long, all strongly acrocentric or nearly telocentric (Fig. 1B). This karyotype corresponds closely to that of *G. fugacissima* (Fig. 1A), a representative species of subgenus *Galaxia*, with a karyotype characteristic of that group.

The karyotype of *Galaxia parva*, with $2n = 12$, is structurally heterozygous. It comprises the following: a long pair of metacentrics, ca. 10 μm long; a mismatched pair ca. 9 μm long, one acrocentric and one metacentric; another mismatched pair 7–8 μm long, also metacentric and acrocentric; a fourth pair of acrocentrics ca. 6.5 μm long; an apparently mismatched fifth pair, one ca. 5.5 and the other ca. 4 μm long; and a very small acrocentric pair ca. 3 μm long. This karyotype has been confirmed for the five individuals of the species so far examined.

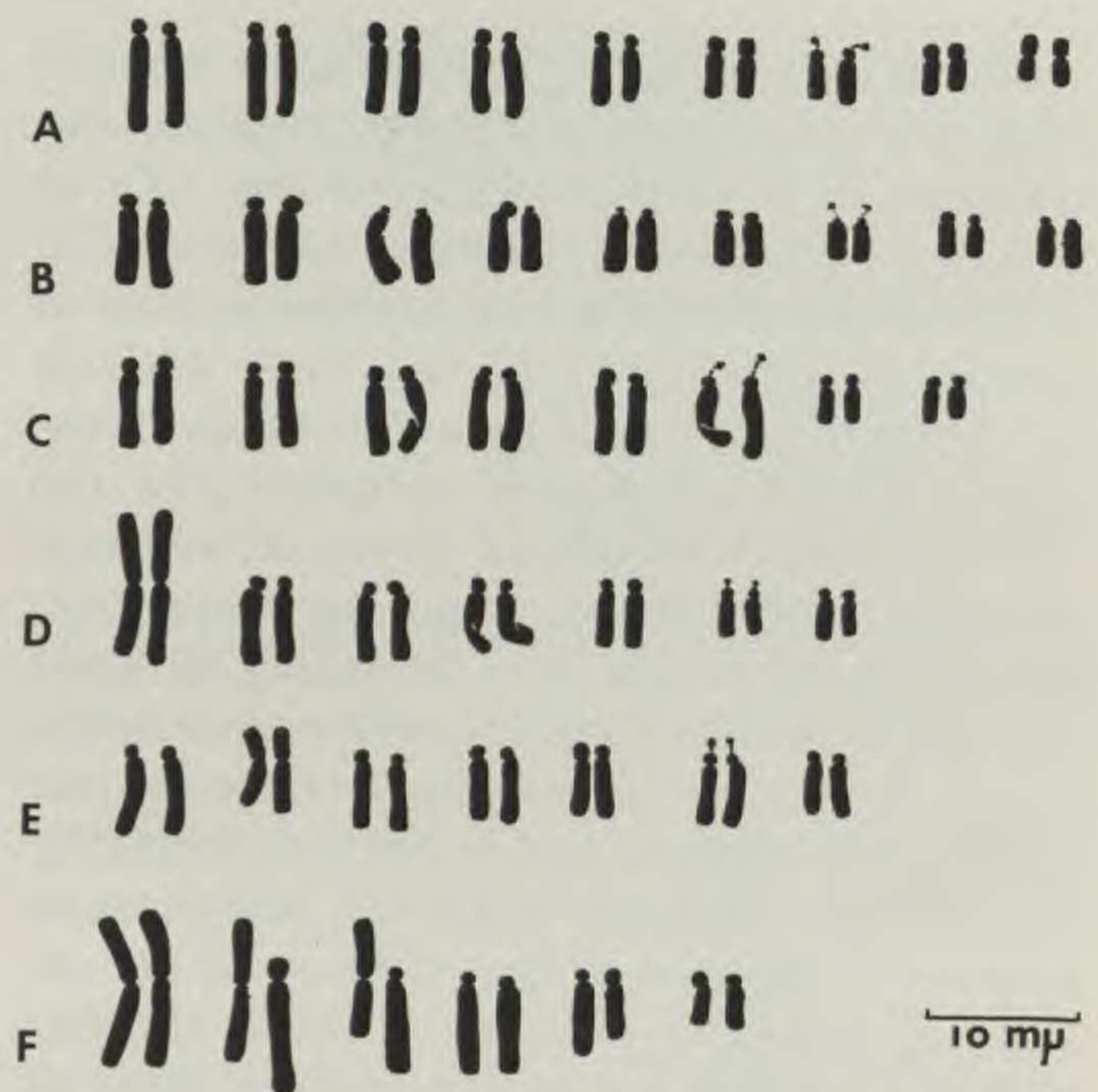


FIGURE 1. Karyotypes of species of *Galaxia*.—A. *G. fugacissima* ($2n = 18$) (subgenus *Galaxia*).—B. *G. kamiesmontana* ($2n = 18$).—C. *G. citrina* ($2n = 16$).—D. *G. versicolor* ($2n = 14$).—E. *G. variabilis* ($2n = 14$).—F. *G. parva* ($2n = 12$) (species B–F all subgenus *Eurystigma*).

Structural heterozygosity has also been recorded in Iridaceae in three species of the allied southern African genus *Homeria* (Goldblatt, 1980), where it is associated with autogamy. These species of *Homeria* were found to form chains or rings of chromosomes at meiosis, and thus constituted complex heterozygotes. The possibility that such a situation prevails in *G. parva*, which is also autogamous, seems likely, but meiotic studies are very difficult to make in *Galaxia* and this remains to be established.

In my review of cytology and karyotype change in *Galaxia* (Goldblatt, 1979b), I proposed the hypothesis that karyotypic evolution had proceeded by decreasing aneuploidy from a basic and relatively symmetric acrocentric complement with $n = 9$ to $n = 8$ and subsequently to $n = 7$. The reduction in chromosome number has been achieved by karyotypic reorganization with minimal loss of chromosome material (Table 1), the overall amount of which is very similar in all diploid species. This reduction is seen as having been achieved in two basic ways: either by unequal but symmetric translocation (Robertsonian fusion); or by unequal asymmetric translocation. In the former, the product is a large metacentric and a small centric fragment, while in the latter a long acrocentric and centric fragment result.

Both processes appear to have taken place in the course of evolution of *Galaxia* subgenus *Eurystigma*. In *G. citrina*, with $n = 8$ (Fig. 1C), as well as in *G. barnardii* and the $n = 8$ form of *G. versicolor*, there is a large acrocentric in place of two small acrocentrics in the basic *Galaxia* karyotype (Fig. 1A). The formation of the karyotype in the $n = 7$ form of *G. versicolor* (Fig. 1D) seems to have involved the fusion of two large acrocentrics to yield the very long metacentric pair in this karyotype. In *G. variabilis*, the same process may have taken place, but involving the fusion of two small acrocentrics to form the pair of long metacentrics found in this karyotype (Fig. 1E). Further unequal reciprocal translocation must have occurred in the evolution of the unusual karyotype of *G. parva*. It seems simplest to postulate that the species evolved from an ancestor with a karyotype like that found in the $n = 7$ form of *G. versicolor* (if not from *G. versicolor* itself), but not only has at least one unequal reciprocal translocation event taken place in the reduction of base number from $n = 7$ to 6, but a certain amount of structural rearrangement presumably occurred subsequently to result in the heterozygous karyotype of this species.

BIOLOGY AND REPRODUCTION

The biology of both *Galaxia kamiesmontana* and *G. parva* exhibits aspects that are unusual in the genus. *Galaxia kamiesmontana* is the earliest flowering species of *Galaxia*, blooming early in the winter, in May or June, typically three weeks after the first soaking winter rainfall. It grows in the rock shelf habitat characteristic for several other species of *Galaxia*. In these rocky sites, the thin covering of soil rapidly becomes waterlogged and because drainage is prevented by the underlying rocky pavement, water remains available to the plants for several weeks even without further rain. *Galaxia kamiesmontana* completes its flowering by the end of June but ripening of the capsules is delayed until late spring or until the soil dries out. Then the stem elongates, pushing the cluster of leaves and ripe fruits well above the ground, before it breaks and the fruit cluster is dispersed by the wind.

Galaxia parva is more typical of the genus in its flowering and fruiting cycle. It grows in the clay soil that is also favored by its allies, *G. versicolor* and *G. variabilis*, and flowers in the early spring. The small, pale flowers open in the late morning and fade at about 3:30 P.M. The species

is self-compatible and, at least in the greenhouse, autogamous, and this breeding system is unique in its subgenus, but is curiously paralleled in subgenus *Galaxia* by *G. albiflora*, a species also having very small, and white, short lasting flowers. Autogamy is known in at least two other species of subgenus *Galaxia*, *G. stagnalis* and the southern populations of *G. fugacissima*, where it seems to have evolved independently.

SYSTEMATIC TREATMENT

***Galaxia kamiesmontana* Goldbl. sp. nov. TYPE:** South Africa. Cape: Kamiesberg, Namaqualand, on Rooiberg, above 4,000 ft. in shallow soil on rock shelves, *Goldblatt 5560* (holotype, MO; isotypes, K, NBG, PRE, S, WAG). Figure 2.

Planta minuta, ad 2 cm alta, tunicis cormi pallido-brunneis, fibris reticulatis costis verticalibus, folia 2–5 falcatis, ad 3 cm longis 1 mm latis, floribus campanulatis pallido-purpureis, infra luteis, tubo perianthii 5–10 mm longo, tepalis 10–12 mm longis unguiculatis, unguibus ascendentibus, limbis horizontalibus 4–5 mm latis, filamentis connatis in columnam ca. 5 mm longam, supra liberis, antheris minus 2 mm longis, ramis styli brevibus ad apices antherae extensis, marginibus stigmatum integribus.

Plants tiny, to 2 cm high when in bloom. *Corm* ovoid, 3–5 mm diam., tunics light brown, fibers reticulate, with a few prominent vertical ribs. *Leaves* 2–5, falcate, lightly channelled or flat, to 3 cm long and 1 mm wide, acute, with broad transparent sheathing bases below the ground, margins smooth. *Stem* underground, reaching to 10 mm above ground as the capsules ripen. *Flowers* campanulate, light purple with yellow nectar guides at the base of the limbs, claws yellow; *perianth tube* 5–10 mm long, cylindrical; *tepals* 10–12 mm long, distinctly unguiculate, claws ascending, forming a narrow cup enclosing the filament column, limbs extended horizontally, the outer to 5 mm wide, inner to 4 mm wide. *Filaments* ca. 5 mm long, united below in a cylindrical column, free in the upper 0.5–1 mm and curving outwards, yellow; *anthers* just under 2 mm long, diverging, yellow. *Style* diverging into three branches at mid anther level, *stigmas* with the lobes shorter than or barely overtopping the anthers, margins entire, minutely ciliate, incurving opposite the anther, radial margins slightly raised. *Capsules* 6–7 mm long; seeds angular, less than 0.5 mm diam. *Chromosome number* $2n = 18$ (*Goldblatt 5560*).

Flowering time. May–June.

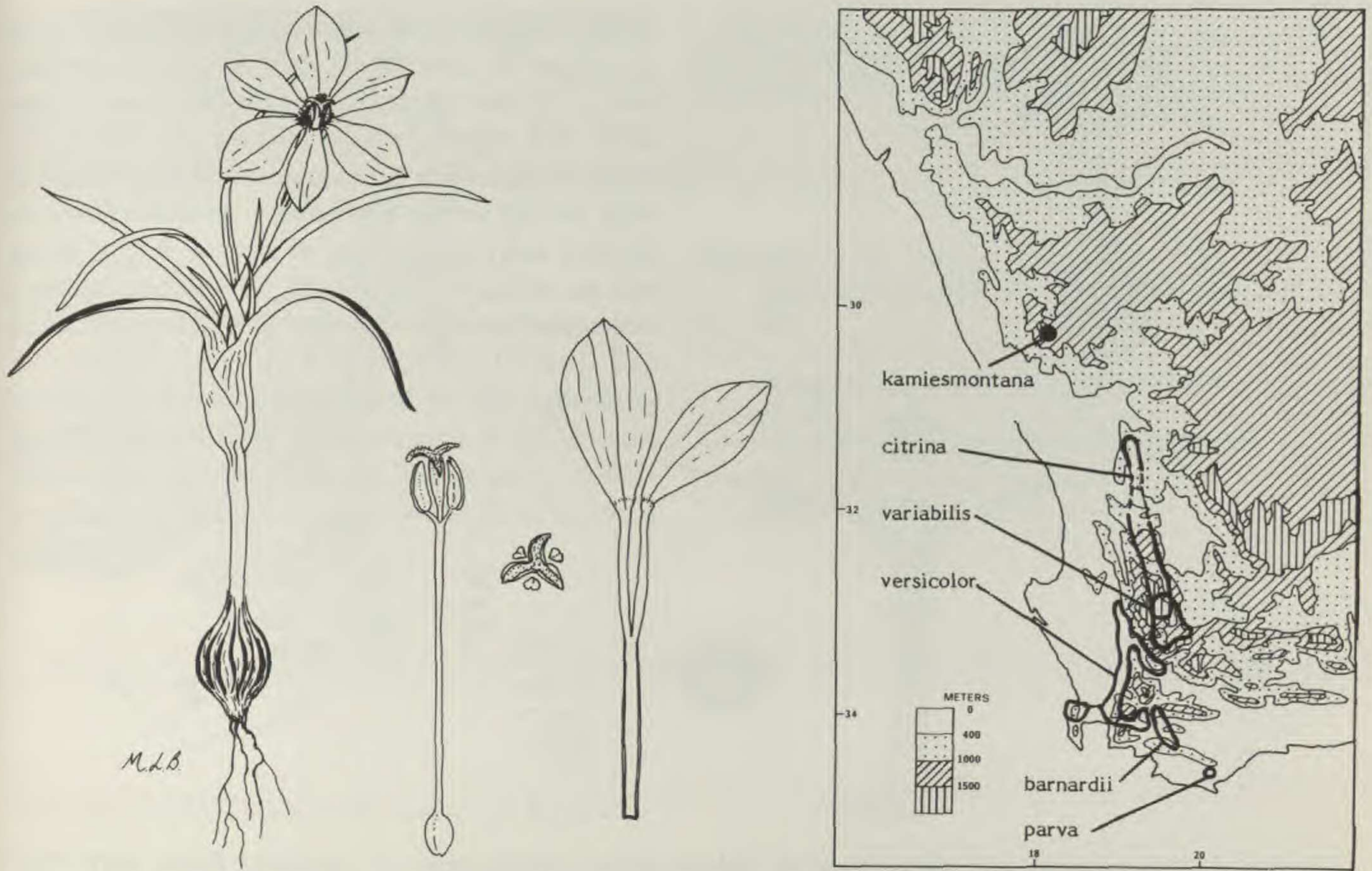


FIGURE 2. Morphology of *Galaxia kamiesmontana* with the distribution of all species of subgenus *Eurystigma*: whole plant and single flower $\times 1$; section of the flower and top view of the stigma lobes much enlarged.

Distribution. Kamiesberg in central Namaqualand, on the Rooiberg above 4,000 ft., in shallow, seasonally waterlogged soil on rock shelves. Figure 2.

Galaxia kamiesmontana is an unusual species, and quite distinct in subgenus *Eurystigma* not only in its small size but in the structure of its flowers. In the other species of *Galaxia* the flowers are campanulate with flaccid, widely cupped tepals, or in *G. barnardii* the flower is hypocrateriform. In either case, there is little distinction between the limb and claw of the tepals. In *G. kamiesmontana*, however, the tepals are clearly clawed. The ascending claws form a narrow cup that encloses the filaments (Fig. 2), and the limbs are sharply flexed at right angles to the tube and extend horizontally.

The rock shelf habitat of *Galaxia kamiesmontana* is typical for the genus, several species of which are restricted to such situations. *Galaxia kamiesmontana* is the most northerly occurring species of subgenus *Eurystigma*, the other five species of which are found in the western part of the Cape Flora Region between Bredasdorp in the south and Nieuwoudtville in the north (Fig. 2).

The karyotype, with a diploid number of $2n = 18$, is unique for subgenus *Eurystigma*, and as described in detail above, the other species of the alliance have numbers of $2n = 16, 14,$ and 12 . The karyotype matches exactly that found in subgenus *Galaxia* and is probably the basic one for the genus. *Galaxia kamiesmontana* appears to be a primitive relict species, surviving in a specialized, seasonally moist habitat in the high mountains of semi-arid Namaqualand.

Specimens examined. SOUTH AFRICA. CAPE: 30.18 (Kamiesberg) Rooiberg, E slopes near Welkom (AC), Goldblatt 5560 (K, MO, NBG, PRE, S, WAG), 5768A (MO); Rooiberg, E slopes of ridge N of the main peak, Goldblatt & Snijman 5588 (MO, NBG, PRE, US).

***Galaxia parva* Goldbl. sp. nov.** TYPE: South Africa. Cape: Mierkraal flats, SSW of Bredasdorp, Goldblatt 6181A (holotype, MO; isotypes, K, NBG, PRE). Figure 3.

Planta parva, 2–3 cm alta, tunicis cormi brunneis, fibris costis verticalibus, foliis plus minusve planis vel canaliculatis, prostratis acutis 15–35 mm longis ad 8 mm latis, floribus campanulatis albis infra luteis cyaneis notatis, tubo perianthii 7–10 mm longo, tepalis 9–12 mm longis, filamentis connatis in columnam ca. 3 mm longam, supra liberis, antheris 1.5–2 mm longis,

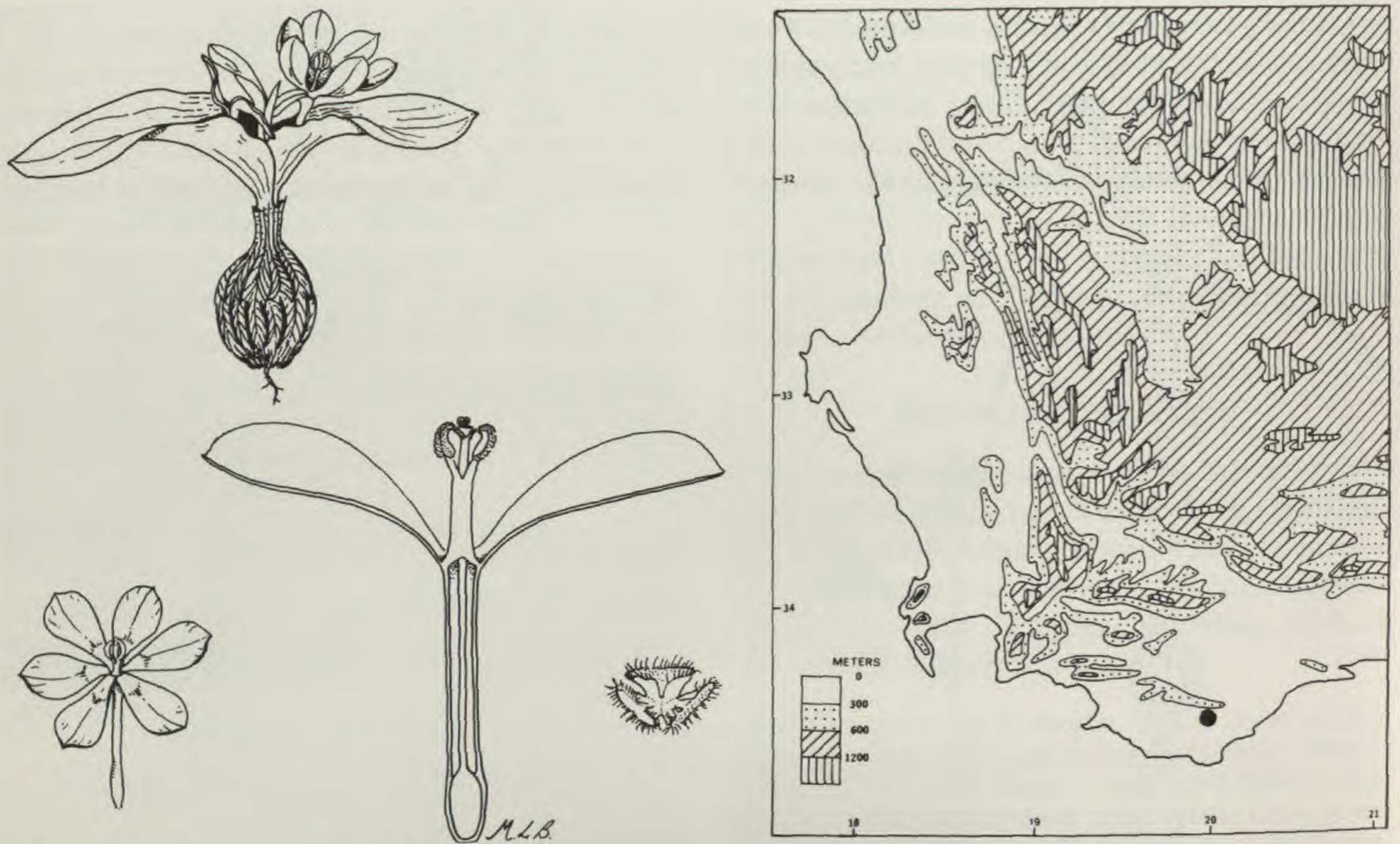


FIGURE 3. Morphology and distribution of *Galaxia parva*: whole plant $\times 1$; dissected flower parts much enlarged.

ramis styli brevibus ad partem mediam antherae extensis, marginibus stigmatum integribus.

Plants solitary, small, 2–3 cm high. *Corm* tunic brown, with prominent woody vertical ribs. *Leaves* 3–4, bifacial, more or less flat or weakly channelled, the outer almost prostrate, acute and acuminate, undulate, 15–35 mm long, to 8 mm wide, margins hyaline, smooth. *Stem* underground, extending 2–4 cm above the ground in fruit. *Flowers* campanulate, white, with turquoise nectar guides and yellow in the center; *perianth tube* 7–10 mm long, cylindrical; *tepals* 9–12 mm long, 5–6 mm at the widest point. *Filaments* 3–4 mm long, united in a cylindrical column below, free in the upper 0.6–1.5 mm and diverging, yellow; *anthers* 1.5–2 mm long, yellow. *Style* diverging near the base of the anthers, and reaching to about the middle of the anthers; *stigma lobes* with entire, minutely ciliate margins, the lobes distinct or more or less continuous at the edges with the adjacent lobes, radial margins slightly raised. *Capsules* not known. *Chromosome number* $2n = 12$ (Goldblatt 6181A).

Flowering time. Late July to early September.

Distribution. Known only from the flats at Mierkraal, SSW of Bredasdorp, on light clay in coastal renosterbos veld. Figure 3.

Galaxia parva has the smallest flowers in subgenus *Eurystigma* but it is in other respects a typical member of the alliance. The species seems most closely related to *G. versicolor*, the pink and purple flowers of which are similar in general shape and proportion, but *G. parva* differs significantly in having a short style so that the stigma lobes reach only to the middle part of the anthers. The pollen is thus in direct contact with the stigmas, and in fact *G. parva* is self-compatible, and at least under greenhouse conditions, autogamous. It is the only species in the subgenus that is not self-incompatible. The small white flower of this species is very similar to that of *G. albiflora* (subgenus *Galaxia*), which is also autogamous and has the smallest flowers in its subgenus. There seems no doubt that the two species are unrelated, and that the small white and yellow flower evolved independently, together with autogamy, in each subgenus.

Galaxia parva has the most easterly distribution of the subgenus, occurring some 50 km from the nearest populations of *G. barnardii*, its closest neighbor in the alliance. It occurs south of the east–west trending Bredasdorp Mts. which isolate it from suitable clay soils that are common to the north and west of the range. It seems likely that *G. parva* evolved from *G. versicolor*

or its immediate ancestors, on a geographically isolated pocket of clay in an area of predominantly sandy or limestone soils to which it is not suited. The evolution of the species has been accompanied by an aneuploid reduction in chromosome number. The base number for the subgenus is $x = 9$, and it has the derived diploid number of $2n = 12$, the lowest number in the genus. The related *G. versicolor* has diploid numbers of $2n = 16$ and 14 (Goldblatt, 1979b). The karyotype, described in detail in the preceding pages, is structurally heterozygous (Fig. 3E) and because the species produces ample seed, its embryology will undoubtedly prove to be of unusual interest.

Specimens examined. SOUTH AFRICA. CAPE: 34.19 (Caledon) flats at Mierkraal, SSW of Bredasdorp (DB), Goldblatt 6181A (K, MO, NBG, PRE).

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